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BALLOON ELECTRICAL ENVIRONMENT PROFILING SYSTEM (BEEPS).(U)
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Final Report to the

Office of Naval Research

(15) Contract N00014-77-C-0154

(6) Balloon Electrical Environment Profiling System (BEEPS).

(9) Final rept.,

Submitted by:

William Marsh Rice University

P.O. Box 1892

Houston, Texas 77001

Prepared by:

(10) Arthur A. Few, Jr.

Principal Investigator

(12) 13

(11) December 1980

305750

Summary

The Balloon Electrical Environment Profiling Systems (BEEPS), was envisaged as a sensory system that could be utilized to obtain a vertical profile of the complete set of atmosphere electrical parameters: (1) vector electric fields, conduction currents, and conductivity. Other objectives were to use high-technology in the design and produce a small system that could be easily launched. All of these design objectives have been met.

The experimental objectives utilizing the systems developed in the program were to obtain atmospheric electrical data in the arctic, where solar-activity perturbations to the upper atmosphere of an electrical nature are known to occur. This objective has likewise been met: two BEEPS were launched from the Naval Arctic Research Laboratory (NARL) at Point Barrow, Alaska.

The scientific goal of finding an electrical coupling between solar activity and tropospheric weather cannot be achieved with two balloon flights but this program has demonstrated the capability of the BEEPS for acquiring the necessary data to test electrical coupling mechanisms within the lower atmosphere.

Milestones

March 1977: Received contract.

March-September 1977: Planning and design specifications.

Beginning September 1977: Prototype payload subassembly construction and testing (M. F. Stewart, engineer); sensor prototype construction and testing (A. J. Weinheimer, graduate student).

November 1977: Meeting with Bob Enderson and Ken Tekrone of Raven Industries to discuss balloon design.

November 1977: Initiation of negotiations with the Naval Arctic Research Laboratory regarding support for balloon operations.

December 1977: Meeting with H. J. Christian (Co-Investigator) regarding program plans and progress.

January 1978: Purchase order for two balloons completed.

February 1978: MFS and AJW went to Raven Industries in Sioux Falls, S. D., to modify balloon gores prior to final assembly of balloons.

Beginning March 1978: Construction and testing of two balloon payloads and two sets of balloon sensors.

May 1978: Shipped ballons, payload, and supporting equipment (shipped air freight) to NARL (5/22/78); personnel departed for NARL (5/23/78 and 5/25/78).

June 1978: Equipment arrived at NARL (6/3-4/78). Presented seminar on BEEPS at NARL (6/1/78). BEEPS-1 flight (6/8/78). Solar Magnetic Sector Boundary Crossing (SMSBC) (6/10/78). (BEEPS launches coordinated with NOAA prediction of SMSBC.) BEEPS-2 flight (6/12/78). Departed NARL (6/14/78).

Beginning September 1978: BEEPS data analysis.

October 1978: Seminar on BEEPS given at Rice University. Presentation on BEEPS at ONR-Arlington.

December 1978: Preliminary results presented at Fall AGU meeting, two papers.

January 1979: AAF and AJW attend workshops on the Role of the Electrodynamics of the Middle Atmosphere on Solar-Terrestrial Coupling.

February 1979: Begin theoretical study for Marshall Space Flight Center on atmospheric electrical coupling.

May 1979: A. J. Weinheimer's M.S. Thesis "Design and Preliminary Evaluation of a Balloon-Borne Instrument for Measuring Atmospheric Electric Profiles" published. No-cost extension to 31 October 1979 given.

November 1979: Request for continued funds declined.

June 1980: Letter to ONR regarding patentability of BEEPS conductivity sensor.

July 1980: Letter from ONR Patent Counsel requesting additional information.

September 1980: Letter to ONR Patent Counsel supplying additional information.

October 1980: Letter from ONR Patent Counsel requesting additional information

December 1980: Final Report -- The question of patentability of the conductivity sensor is still outstanding, but we decided to file the final report in order to "close the books" on this contract.

Conclusions

The BEEPS performed as designed and clearly demonstrated the possibility of measuring vertical profiles of the atmospheric electrical parameters with small balloon systems. The only surprise element that we had not anticipated was the effect of turbulence around the balloon in the early part of the flight owing to the very rapid rise rate. This turbulence interferred with the conduction current measurement but not detrimentally with the electric field or conductivity. We detected a small change in the positive conductivity in the lower arctic stratosphere between the two BEEPS flights. (BEEPS-1 did not reach its peak design altitude owing, we think, to a premature firing of the positive recovery system; however the data received was sufficient to see this lower stratospheric effect.) We have no way, with just two measurements, of determing if this observed difference is related to the solar magnetic sector boundary crossing or some other natural occurence.

We believe that the results prove that BEEPS can perform the task for which it was designed and that this system should be deployed as a part of a coordinated research effort utilizing high altitude ballons, satellites, radar, etc. to study the atmospheric electrical coupling problem from space down to the Earth's surface.

The concept development, proof of concept, and flight testing of the BEEPS is completed. Our work will continue to see that the information generated in this first phase and that the theoretical investigations from the NASA-MSFC supported research is published. We believe it is now appropriate to plan for a next phase in the research area.

Appendix

Contents:

(1) Abstract of paper at 1978 Fall AGU meeting.

(2) Abstract of paper at 1978 Fall AGU meeting.

(3) Copy of news article from the December 16, 1978 issue of Science News.

(4) Copy of M.S. thesis of A. J. Weinheimer (only in copy for ONR-Arlington).

(5) Copy of Ph.D. thesis of A. J. Weinheimer (only in copy for ONR-Arlington).

with modes at around 0.1 μm and 2.0 μm particle diameter. The number concentration at the upper mode is strongly variable in space and time. The effects on the aerosol size distribution and on the optical properties of the atmosphere of altitude (distance from sources), cloud nucleation, city pollution and power plant effluents are presented and discussed.

M 97

AEROSOL CHARACTERISTICS AT CEDAR MOUNTAIN, UTAH

R. F. Pueschel
P. A. Allee, (both at: ERL/NOAA, Boulder, Co. 80303)

Aerosols were measured at Cedar Mountain (39° 11' N; 110° 37' W, 2336 m MSL) in support of a visibility study. In situ measurements by aircraft show that in the lower boundary layer the aerosol size distribution has modes at 0.1 μm and 1.0 μm within the diameter range 0.08 μm ≤ D ≤ 50.0 μm. Supportive analysis of filter deposits of aerosols by scanning electron microscopy and X-ray energy dispersive spectrometry shows that the two modes correspond to two different size distributions that are chemically and physically distinctive: The aerosol dominating the lower particle mode consists of spheres made up of elements lighter than sodium; the aerosol dominating the mode at 1.0 μm consists of both spherical and nonspherical particles of elements heavier than sodium. Sulfur is the abundant element, followed by silicon, calcium, aluminum. Changes in the physical and chemical aerosol characteristics were not strong enough to explain changes in visibilities that were observed between January and July, 1977. It is concluded that visibility is most strongly effected by the total aerosol concentration which is determined by advective and convective processes of the atmosphere.

M 98

POSSIBLE EFFECTS OF ANTHROPOGENIC SULFUR SOURCES ON THE STRATOSPHERIC SULFATE AEROSOL LAYER

J. Pollack
O.B. Toon
R.C. Whitten (all at NASA-Ames Research Center, Moffett Field, CA 94035)
S.P. Turco (S and D Associates, Marina del Rey, CA 90291)
P. Hamill (Systems and Applied Sciences Corp., Hampton, VA 23666)

Aerospace activities in the high atmosphere and release of carbonyl sulfide in the troposphere can perturb the stratospheric aerosol layer. It has been suggested, for example, that space shuttle rocket engines might deposit a significant number of aluminum oxide particles of small size in the upper atmosphere; these particles could serve as condensation nuclei for H_2SO_4 leading to new, large H_2SO_4 particles and could thus significantly alter the optical depth of the aerosol layer. Future aircraft flying in the lower stratosphere could also cause perturbations to the aerosol layer because they emit sulfur dioxide and soot formed in engine combustion processes. Finally carbonyl sulfide from surface industrial sources will rise to the stratosphere where it is photolyzed; the sulfur atoms so produced undergo a series of reactions leading to sulfur dioxide and eventually sulfuric acid. Using the Ames stratospheric aerosol model and appropriate radiation models, we have assessed sulfur sources in terms of possible mean surface temperature changes. The effects of aerospace sources are quite small (surface temperature changes of 0.01°C or less), but under certain conditions carbonyl sulfide emissions might be significant.

Thunderstorms and Atmospheric Electricity

Goldrush (HI), Friday 0830h

Roy T. Arnold (Physics Department, University of Mississippi), Presiding

M 99

MEASUREMENTS IN THE TURBULENT ELECTRODE LAYER OVER LAND

J. C. Willett (Naval Research Laboratory Code 8320, Washington, DC 20375)

A recent extension of the theory of the turbulent electrode effect was tested in two field experiments. Daytime, fair-weather profiles of positive and negative conductivity in the lowest 5m above the ground were measured at various mean wind speeds. The total current flowing to flush-mounted Wilson plates was compared between one antenna covered with a chicken-wire screen and another exposed to the ambient field. The results of the former experiment tend to support theoretical predictions that the profiles of the two components of conductivity approach one another as the turbulence intensity increases and that both components decrease toward zero as the ground is approached. The latter experiment indicates that the partition of total current density into conduction and convection currents is different from that predicted by theory near the surface.

M 100

MEASUREMENT OF ATMOSPHERIC ELECTRIC SPACE CHARGE DENSITY FLUCTUATIONS

R. V. Anderson (Naval Research Laboratory, Code 8325, Washington, DC 20375)

An instrument is described which is designed to be selectively sensitive to turbulent fluctuations of atmospheric space charge density in eddy size ranges as small as 5 cm. The instrument consists of a doubly screened Faraday cage made in the form of a 7.5 cm cube of wire mesh screening which is maintained at ground potential through a sensitive electrometer which has useful frequency response up to several hundred Hertz. A double layer of grounded shield screening isolates the measuring element from external electrostatic fields; allowing it to respond only to the net atmospheric charge within its volume. Natural ventilation of the sensor produces an output current proportional to changes in this volumetric charge. The instrument is described, and data spectra are presented indicating agreement with the theory of turbulent mixing of atmospheric charges.

M 101

TIME-DEPENDENT ELECTRIC FIELDS IN CLEAR AIR AND MODEL CLOUDS

W. L. Boeck (Dept. of Physics, Niagara University, NY 14109)

Calculations have been made to specify the time-dependent electrical environment in which cloud physical processes occur. Particular attention is paid to electric fields with periods from 1 to 20 minutes at altitudes between 2 and 12 kilometers. The cloud model is dynamically and electrically passive without any form of convective transport or separation of charge. The differential equation, valid when the total current (conduction current and displacement current) is divergence free, has been solved. The electric field as a function of frequency and altitude has been evaluated for an atmosphere with a conductivity profile as given by Cole and Pierce. The propagation of the field depends strongly on the ratio of conduction current to the displacement current. When the displacement current is dominant the atmosphere with or without clouds is transparent to time dependent electric fields (i.e.), there is very little difference between the field at cloud levels and at ground level. When the conduction current is dominant, the electric field is essentially equal to the air-earth current density divided by the local conductivity. The change in air-earth current due to the model cloud has been evaluated. The net effect on the time dependent electric field within a cloud, is that the magnitude of the electric fields are somewhat smaller than the values predicted from direct current theories.

M 102

ATMOSPHERIC ELECTRICAL MEASUREMENTS AND THE SOLAR MAGNETIC SECTOR STRUCTURE

Andrew J. Weinheimer
Arthur A. Few, Jr. (both at: Dept. of Space Physics and Astronomy, Rice University, Houston, TX 77001)
Hugh J. Christian, Jr. (Research and Development Division, New Mexico Institute of Mining & Technology, Socorro, NM 87801)

A balloon-borne instrument has been developed for the purpose of making fair weather atmospheric electrical measurements. The instrument, named Balloon Electrical Environment Profiling System (BEEPS), is similar in principle to balloons flown previously into thunderstorms by our group at Rice. It has the capability of measuring the height profiles of the vector electric field, the atmospheric conduction current, and the polar conductivities. The balloon was designed to make measurements up through the lower polar stratosphere (14 km), and the first two flights of BEEPS have been made in conjunction with a solar magnetic sector boundary crossing, with one flight on either side of the boundary. These flights are a first step in an effort to measure and understand the electrical response of the atmosphere, as a function of altitude, to the solar sector structure. Knowledge gained from such flights may prove valuable to the development of an understanding of those aspects of the sun-weather problem that also involve the solar sector structure. Results from these flights will be presented along with a brief description of the instrument.

M 103

MEASUREMENTS OF THE ELECTRICAL EVOLUTION OF A NEW MEXICO THUNDERCLOUD.

M. J. Christian
C. B. Moore
S. J. Munyady (all at: New Mexico Institute of Mining and Technology, Socorro, NM 87801)
J. W. Bullock (Airo, Inc. P.O. Box 731 Colorado Springs, CO 80910)

On 17 August 1977 we studied an isolated thundercloud, centered approximately four kilometers north-east of Langmuir Laboratory, with the CMR/NMIMT Schweitzer airplane and our vertically scanning 3 cm cloud physics radar. The cloud formed soon after 09:00 MST and the initial radar echo was detected around 10:08. The echo intensified thereafter and a precipitation shaft was observed near cloud base after 10:16 MST. The airplane made its initial penetration of the cloud at 10:05 MST and made a total of twenty-two penetrations over the next hour and a half. The time lapse photographs show vigorous turrets growing from the lower cloud starting at about 10:28 MST.

At 10:30 MST the vertically-scanning radar indicated a peak reflectivity of 48 dbZ, equivalent to a rain rate in excess of 10 mm/hr. All of our electric field measurements indicated negligible cloud electrification up to this time. The cloud became electrified shortly before 10:32 MST. An airplane penetration at 10:32:30 MST measured a maximum field strength of 7 KV/m; the first lightning occurred at 10:36:52 MST. Electric field strengths greater than 100 KV/m were measured on subsequent penetrations. The cloud turrets reached their apexes at 11:05 MST and subsided thereafter. The frequent lightning ended after a discharge at 11:05:53 MST although rain continued to fall from the cloud until 11:30 MST.

In this relatively simple storm, the electrical activity seemed to be strongly correlated with the vertical development of the cloud. Our observations are similar to those reported earlier by Byers & Braham and by Reynolds and Brook.

M 104

ELECTRICAL POWER FROM PRECIPITATION MECHANISMS FOR THUNDERSTORM ELECTRIFICATION

E.R. Williams (Dept. of Earth and Planetary Sciences, MIT, Cambridge, Ma. 02139)

Theories of thunderstorm electrification based on gravitational separation rely on the gravitational potential energy of precipitation which is but a small fraction (1-5%) of the thunderstorm energy budget. To obtain a realizable upper bound on the steady state electrical power available in precipitation mech-

and decayed into density fluctuations at about 1.4 AU from the sun. Strong deceleration commenced at about 0.4 AU from the sun in the case of the disturbance generated by the solar flare on April 30/21h, 1976. These examples suggest the existence of strong plasma deceleration. On the other hand, the disturbance generated by the solar flare on Aug. 7/15h, 1972 propagated with constant speed (1000 km/sec) as far as 2 AU from the sun.

*NAS-NRC Post-Doctoral Associate.

SS 42

SIMULATION OF AN INTERPLANETARY PERTURBATION BY A TIME-DEPENDENT, TWO-DIMENSIONAL, MHD NUMERICAL MODEL

C. O'Dutton (C.E.S.R., Université Paul Sabatier, 31029 Toulouse Cedex, France)
M. Dryer (Space Environment Laboratory, NOAA/ERL, Boulder, Colorado 80303)
S. T. Wu
S. M. Rao (both at: University of Alabama in Huntsville, Huntsville, Alabama 35807)

A numerical code is used to investigate the influence of several parameters of an initial pulse at 18 R_s on the propagation and the development of a perturbation in an angular sector of the equatorial plane of the sun. This code was first used by Wu, Rao and Dryer (Planet. Space Sci., 1979, in press) to solve a set of equations for a time-dependent, two-dimensional MHD model for a one fluid solar wind with adiabatic expansion. The sector of the solar equatorial plane is 90° wide and extends from 18 R_s to 226 R_s. The initial pulse is set arbitrarily at the inner boundary assuming that a shock wave is already formed. Its parameters are the velocity of the shock front, the angular width of the perturbation and its duration at 18 R_s. The influence of these parameters have been tested. It is shown that in any case the time delay between 18 R_s and 226 R_s depends on the total amount of energy released by the pulse; this dependence is stronger with the initial shock velocity than with the angular width. Also it appears that the shock wave propagates according to a power law of the inverse of time ($R=t^{-\alpha}$). Another result is that the longitudinal extent of the perturbation at 1 AU seems to be only a function of the time elapsed after the arrival of the shock front at this distance. It is also shown that the reverse shock which is formed after a few hours reaches only a limited extent in longitude relative to the central direction of the pulse.

SS 45

PIONEER 10 OBSERVATIONS OF INTERPLANETARY SHOCK WAVES BEYOND 6 AU HELIOCENTRIC DISTANCE

J.D. Mihalov
W.R. Collard
J.H. Wolfe (all at: NASA-Ames Research Center, Moffett Field, CA 94035)

Twenty-two corotating-type interplanetary shocks have been tentatively identified in the Pioneer 10 Ames plasma analyser data from December, 1974, to July, 1975, as the spacecraft traveled from 6.2 to 7.7 AU heliocentric distance. Hourly samples of solar wind plasma parameters were used to locate candidates for shocks, and then more detailed data were inspected. The signatures of 12 of these appear to be those of forward shocks. Because of non-continuous spacecraft tracking, 11 of the 22 tentative shock events occurred in a data gap at least 3 hours long. When compared and combined with the shock statistics of Smith and Wolfe for Pioneer 10 and 11 data to December, 1974 (STIP/77 Meeting), an occurrence rate of about 10 per 100 days is obtained for the 1974-5 data, and about 16 per 100 days for 1973, when the two spacecraft are at less than 5.1 AU heliocentric distance. The proportions of forward and reverse types appear about the same for all the observations. The increase in convective energy across a forward shock at 7.7 AU can be as large as 4×10^{-10} ergs/cm^2.

SS 46

INTERPLANETARY DISCONTINUITIES: TEMPORAL VARIATIONS AND THE RADIAL GRADIENT FROM 1 to 8.5 AU

E. J. Smith
B. T. Tsurutani (both at: Jet Propulsion Laboratory, Pasadena, CA 91103)

Interplanetary discontinuities have been investigated at heliocentric distances between 1 and 8.5 AU using Pioneer 10 and 11 vector helium magnetometer observations. The principal purpose of the study was to investigate a possible dependence of the rate of occurrence and properties of the discontinuities on radial distance. This objective required a separation of spatial and temporal variations using the simultaneous, nearly continuous data from both spacecraft. Discontinuities were identified using carefully developed criteria that were shown to be comparable to those used in earlier studies but which are still applicable in the weak magnetic fields typical of large radial distances. Temporal changes in the rate of occurrence averaged over Bartels solar rotations were well correlated at Pioneer 10 and 11 which were separated by a distance of ~ 2 AU. The time variations consisted of a slow modulation of the rate of occurrence such that successive increases and decreases persisted for several months at a time, presumably as a result of changing solar conditions. The correlation over widely separated distances is most simply interpreted by a model in which the discontinuities originate inside 1 AU, probably near the Sun, and are convected outward by the solar wind. Clear evidence of a decrease in the rate of occurrence, p, with distance has been obtained. The simultaneous rates from the two spacecraft reveal that this decrease is well approximated on the average by the function, $p=50\ e^{-(R-1)/4}$ implying a radial gradient of 25% per AU. This gradient may be apparent and does not necessarily imply that discontinuities actually occur less frequently at large radial distances. The decreased rate of occurrence may be associated with an increasing thickness of the discontinuities.

SS 45

SOLAR CYCLE-DEPENDENT NORTH-SOUTH FIELD CONFIGURATIONS OBSERVED IN SOLAR WIND COROTATING INTERACTION REGIONS

Ronald L. Rosenberg (both at: Dept. of Geophys. and Planetary Phys., UCLA, L.A., CA. 90024)
Paul J. Coleman, Jr. (also at Dept. of Earth and Space Science, UCLA)

The results of superposed epoch analyses of IMF components in corotating interaction regions observed with Pioneer 10 in 1972-3 from ~7.5° to +5.4° and 1 to 5 AU indicate that in about two-thirds of the regions, at both earth and south heliographic latitudes, the N-S component, B_N, was enhanced and negative in the forward portion (observed first). The rear portion had an enhanced positive B_N. The azimuthal component also was enhanced and reversed sign. Superposed epoch analyses of B_N in interaction regions as determined with other spacecraft from 1964-1973 indicated a similar systematic configuration. In pre-1970 data the forward portion of the interaction regions had enhanced northward B_N, on the average. The B_N configuration reversed phase near the beginning of 1970 as did the dipolar-related dominant polarity effect. The observed field configuration can be described for the model of the IMF in which a near equatorial current sheet separates fields of opposite polarity derived from the extension of the solar dipole-like field. Perturbations in the vicinity of an interaction region cause the field lines representing the IMF to bulge away from the current sheet in the majority of cases.

SS 46

INTERPLANETARY CURRENT SHEET AND MAGNETIC FIELD SECTOR STRUCTURE

E.L.G. de Gonzalez
W.D. Gonzalez (both at: Instituto de Pesquisas Espaciais-INPE, Conselho Nacional de Desenvolvimento Cientifico e Tecnológico-CNPq, 12200 São José dos Campos, SP, Brasil)

Some evidences of a short and long term behaviour of the interplanetary magnetic field sector structure, based on statistical studies carried out with daily values of the polarity of the interplanetary magnetic field, will be presented. This study supports the idea of an interplanetary current sheet somewhat tilted with respect to the ecliptic plane, giving rise basically to a long term two sector pattern for the interplanetary magnetic field observed at Earth. Some consequences of the interaction of the interplanetary current sheet and associated magnetic structure (involving sectors, kinks and folds) with magnetospheric currents will be discussed.

SS 47

SECTOR BOUNDARY PASSAGE FORECASTING

G. R. Heckman (Space Environment Services Center, NOAA, Boulder, Colo. 80303)
P. H. Scherrer (asst. for Plasma Research via Crespi, Stanford, Calif. 94305)
A. J. Weinheimer (Space Physics Dept., Rice University, Houston, Texas 77001)

In June of 1978, the Space Environment Services Center successfully forecast a significant solar sector boundary passage in support of a short series of scientific balloon launches conducted by Rice University at Point Barrow, Alaska. Daily solar mean magnetic field measurements, made at Stanford, and inferences of the interplanetary magnetic field direction, based on the strength of the Thule, Greenland magnetic field 2-component, were used to make the forecasts. The technique of forecasting selected significant boundary passages is described, as well as the method of monitoring the interplanetary field direction to determine, to near real time, whether the predicted passage has actually taken place. The prediction of significant boundary passages is thought to be useful to the research community; thus, a new limited SESC service (involving forecasts and alerts of significant boundary passages) is announced.

Tectonophysics

Trenches, Arcs, and Back Arc Basins of the Western Pacific: General Results of DSDP and General Papers

El Dorado (JT), Monday 0800h

Robert Scott (Dept. Geology, College of Geosciences, Texas A & M Univ.), and

George Klein (Dept. Geology, Univ. of Illinois), Presiding

1 :

DRILLING RESULTS FROM LEG 58, DSDP, IN THE SHIKOKU BASIN AND DAITO RIDGE-AND-BASIN PROVINCE OF THE NORTHWESTERN PHILIPPINE SEA

George deVries Klein, Dept. of Geology, Univ. of Illinois at Urbana-Champaign, Urbana, IL, 61801
Katuo Kobayashi, Ocean Research Inst., Univ. of Tokyo, 1-15-1 Minamidai, Nakano-ku, Tokyo 164, Japan
LEG 58 Scientific Staff

Leg 58 drilled three sites (442,443,444) in the Shikoku back-arc Basin and two in the Daito Ridge-and-Basin province (445,446). Shikoku Basin sites penetrated hemipelagic clays overlying tholeiitic pillow and intrusive basalts. Basalt sills intruded both sediments and pillow lavas. Age of oldest sediments was 18-21 myBP (442), and 14-15 myBP (443,444). Oldest sediment age at 442 coincides with magnetic anomaly 6 age for this site, whereas oldest sediment ages at 443 and 444 are at variance with magnetic anomaly 6A age for those sites. These results show that the Shikoku Basin was characterized by a history of post-spreading, off-ridge volcanism that obscured true sediment/basement ages, and may account for the high heat flow and rough topography of the basin. Our data appear compatible with all proposed spreading models suggested for the basin.
The Daito Ridge-and-Basin Province sites (445, 446) consist of an upper pelagic interval and a lower section of volcaniclastic turbidites intruded by 21 basalt sills at 446). Magnetic inclination data suggest that this region drifted north a distance of 1,000 km from an equatorial latitude during the past 51 my. Although basement was not reached, drilling terminated

EARTH SCIENCES

Susan West reports from San Francisco at the fall meeting of the American Geophysical Union

Adding to the ocean crust mystery

Until Woods Hole Oceanographic Institution's *Alvin* took a closer look at the mid-Atlantic Ridge during the summer of 1978, oceanographers thought only one type of basalt — called pillow basalt because of its frothy appearance — was pushed out of the spreading ridges onto the ocean crust. But, says H. Paul Johnson of the University of Washington, *Alvin*'s deep-towed camera confirmed what earlier work on the Galapagos Rift suggested: that basalts also exist in thin horizontal sheets and in thick, massive units.

Johnson says the three types may represent different stages of ridge activity. The thick units may represent rapid outpourings of magma along very young, long fissures. The thin sheets may mark slower flows from narrowed channels and the pillows could result as the sources of magma close to a single point.

The pillow basalts — which have been extensively studied — were thought by some to account for the magnetic structure of the ocean crust alone, says Johnson. Now, he says, researchers will have to consider the magnetic properties of all three types. "They represent a third of the ocean crust we just didn't know was there," he says.

Solar magnetic field polarity: Part one

The polarity of the sun's magnetic field changes as it rotates. The point where it changes is called a sector boundary crossing. The irregular changes in polarity have been postulated to cause electrical changes in the earth's atmosphere which in turn may affect the weather (SN: 12/31/77, p. 423).

Last June, when researchers at Rice University decided to study the possible electrical changes before and after a boundary crossing, they found one small problem: They had *no* way to tell when a crossing would occur. Gary Heckman, chief of the National Oceanic and Atmospheric Administration's Space Environment Services Center in Boulder, Colo., came to their rescue. At the meeting, he described the first attempt — and a successful one — to predict a boundary crossing.

A telescope at Stanford University's Institute for Plasma Research measures the mean magnetic field of the sun — the sum of the polarities of the regions of the sun facing earth. A ground-based magnetometer at Thule, Greenland, allows researchers to infer the direction of the sun's magnetic field and thus mark the date of polarity changes after they occur.

Having monitored the mean magnetic field and the sector boundary crossings, Heckman and his group knew that the crossings typically are registered on earth three-and-a-half to four-and-a-half days after the mean field, as measured from Stanford, nears zero. When the Rice researchers contacted Heckman at the last minute from their launch site in Point Barrow, Alaska, the NOAA group came up with two dates which they predicted would just straddle the crossing. They picked the exact crossing date within one day. Real-time data, from the ISEE-C satellite for example, could pinpoint the crossings even more precisely, says Heckman.

Solar magnetic field polarity: Part two

Andrew J. Weinheimer of Rice University was there to complete the story. The boundary crossing studies marked the first two flights of a balloon-borne instrument called BEEPS (Balloon Electrical Environment Profiling System). While other similar instruments hang below the balloon as it carries them aloft, BEEPS sits inside. In addition, the aluminum-coated surface of the four-meter-diameter balloon is actually part of the instrument; the static electricity created by the plastic balloons of other systems often interferes with measurements. Taking continuous readings up to 14 kilometers, the system measures the electric field intensity and direction, the ability of the air to conduct electricity and the air-to-earth current.

Based on their preliminary data, Weinheimer said the atmospheric electrical property most affected by the change in solar magnetic field polarity seems to be conductivity. The positive ion conductivity — the ability of positive ions to carry conductivity — appears to have been greater before the polarity change than after it, he said. The Rice team hopes to have BEEPS monitor the same properties daily for an entire 27-day solar rotation.

Measuring continent growth

James R. Lawrence of Lamont-Doherty Geological Observatory has calculated that the continents may have grown a minimum of five percent and a maximum of 40 percent during the past three billion years. If, as some researchers believe, the uppermost ocean sediments riding atop the ocean plates are scraped off as the plates move under the continents, the continents have grown by five percent, Lawrence says. Based on measured fluctuations of O^{18} in deep ocean sediment cores, Lawrence says additional material from the volcanic layer of the ocean crust — called layer two — may have increased the continents another 35 percent.

The concentration of O^{18} depends on the type of reaction that occurs between the ocean crust and seawater. Low temperature reactions between ocean basalts and seawater use up O^{18} and create hydrous material.

Because of its high water content, such material is not likely to descend into the mantle without further alteration. High temperature reactions, on the other hand, produce O^{18} and easily subducted material. Because the ratio of O^{18} to O^{16} in the ocean crust has remained constant over geologic time, Lawrence observed that either more high temperature reactions must occur or the O^{18}-depleting hydrous rock must be removed in order to preserve the ratio. The measurements of O^{18} fluctuations indicate that not enough high temperature alteration occurs for that process alone to be responsible for maintaining the oxygen isotope ratio. However, Lawrence says, five to 15 percent of the volcanic layer is hydrous. The addition of this material to the continents, which would increase their sizes by as much as 35 percent, could preserve the proper isotope ratio.

Interpreting seismic wave decay

Seismologists have long been able to use changes in the speed of seismic waves to determine the thickness of the crust and the size of the earth's core. However, they have not known how to interpret the varying rates at which seismic waves decay or die away. Don L. Anderson of California Institute of Technology described a theory based in materials science that may allow scientists to quantify the physical conditions reflected by changing decay rates.

Imperfections in crystals determine how they respond to different physical conditions. Laboratory tests of stress and temperature on crystals show that they absorb more energy under higher stress and at higher temperature. Anderson and coworker J. B. Minster postulate that the same mechanisms operate in the mantle: Where the mantle temperature is high, the energy of seismic waves will be absorbed quickly and the waves will decay very rapidly. Likewise, areas of high stress will absorb energy quickly and seismic waves will not propagate far. Laboratory-determined calibrations will allow scientists to infer temperature distribution in the earth's mantle and to track stress buildup, Anderson says.

RICE UNIVERSITY

DESIGN AND PRELIMINARY EVALUATION OF A BALLOON-BORNE INSTRUMENT FOR MEASURING ATMOSPHERIC ELECTRICAL PROFILES

by

ANDREW JOHN WEINHEIMER

MASTER OF SCIENCE

HOUSTON, TEXAS
MAY, 1979

RICE UNIVERSITY

THE ROTATIONAL DYNAMICS OF ATMOSPHERIC ICE: ELECTRICAL AND AERODYNAMIC TORQUES

by

ANDREW JOHN WEINHEIMER

DOCTOR OF PHILOSOPHY

HOUSTON, TEXAS
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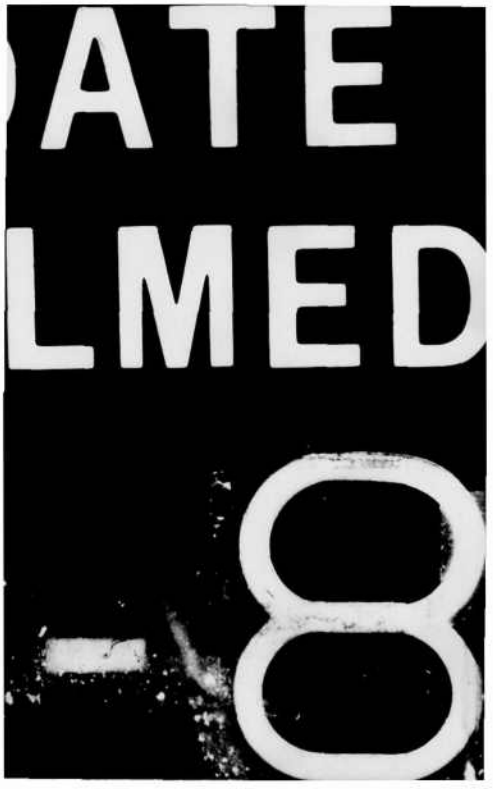
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